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A hemispheric asymmetry for the unconscious perception of emotion

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Abstract

Previous research has demonstrated that hemispheric asymmetries for conscious visual perception do not lead to asymmetries for unconscious visual perception. These studies utilized emotionally neutral items as stimuli. The current research utilized both emotionally negative and neutral stimuli to assess hemispheric differences for conscious and unconscious visual perception. Conscious perception was measured using a subjective measure of awareness reported by participants on each trial. Unconscious perception was measured by an "exclusion task," a form of word-stem-completion task. Consistent with predictions, negative stimuli were consciously perceived most often when presented to the right hemisphere. Negative stimuli presented to the right hemisphere showed no evidence of unconscious perception, suggesting that the hemispheric asymmetry for the conscious perception of negative information occurs at the expense of unconscious perception.

1. Introduction

Although there are distinct differences in the perceptual abilities of the two cerebral hemispheres when stimuli are *consciously* perceived, these asymmetries do not necessarily lead to different levels of *unconscious* perception[1] (Smith & Bulman-Fleming, 2001). For example, Smith and Bulman-Fleming (2001) performed two experiments in which the presentation parameters favoured the abilities of one hemisphere or the other. In one study, stimuli were presented for a very brief exposure duration (17 ms), a display that should have favoured the right cerebral hemisphere (RH; Sergent, 1983). In another study, stimuli were followed by a mask (e.g., &&&&&&) that disrupted the conscious perception of the items, a display that should have favoured the left cerebral hemisphere (LH; Nicholls, 1996). Both experiments resulted in the predicted hemispheric advantages when the stimuli were consciously perceived. In contrast, no asymmetries were found when the stimuli were unconsciously perceived; both hemispheres showed equivalent levels of unconscious perception in both experiments. However, the stimuli used in these experiments were relatively neutral in affect. The current research assesses whether emotional stimuli will influence the levels of unconscious perception in the two cerebral hemispheres.

Using emotional stimuli could alter the pattern of results because the two hemispheres show differential specialization for the processing of emotion. Proponents of one theory of this asymmetry, the "right-hemisphere hypothesis," suggest that the RH is uniquely skilled at processing emotion and that the LH has, at best, a supporting role in emotional perception (e.g., Borod, Kent, Koff, & Martin, 1988). Proponents of a second theory, the "valence hypothesis," suggest that the RH is specialized for the perception and generation of negative or avoidance-related emotions whereas the LH is specialized for the perception and generation of positive or approach-related emotions (e.g., Davidson, 1995). Although these theories would lead to different predictions for the perception of positive information, both would predict that the RH would be superior to the LH at processing negative information. The current research will therefore focus on negative information in order to assess the role of emotion on the lateralization of unconscious perception.

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[1] The terms "perception without awareness" and "unconscious perception" are used interchangeably in this paper, as are the terms "emotion" and "affect."

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Previous investigations of hemispheric asymmetries and unconscious perception have generally shown a RH advantage for the discrimination of affect. Stambrook and Martin (1983) presented faces expressing positive, negative, or neutral emotion. The stimuli were presented to one visual field; a silhouette of a face was presented to the alternate visual field simultaneous with the presentation of the face. The faces and silhouettes were presented at exposure durations both above and below the participants' awareness thresholds. Participants were asked to state the visual field in which the face appeared and to state the emotion expressed by the face. Stambrook and Martin (1983) found a RH advantage for locating the face. This result is not surprising given the right hemisphere's superiority at face processing. Critically, there was also a slight RH advantage for discriminating affect. The RH superiority was more pronounced for negative than for positive faces, thus supporting the valence hypothesis discussed above.

Recent neuroimaging studies also support the hypothesis that the RH is superior to the LH at the unconscious perception of emotion. Whalen et al. (1998) found that the right amygdala is sensitive not only to unconsciously perceived emotional stimuli, but can differentiate between positive and negative emotions that are perceived without awareness. Specifically, the right amygdala shows *increased* activation levels when fear-related stimuli are presented and shows *decreased* activation levels when happiness-related stimuli are presented. Thus, there is neurophysiological and behavioural evidence that the RH, but not the LH, is sensitive to the unconscious perception of emotion.

However, in addition to being few in number, most investigations of hemispheric asymmetries for the unconscious perception of emotion contain a methodological confound. Specifically, in these studies, conscious and unconscious perception do not lead to qualitatively different patterns of data (Reingold & Merikle, 1990). For example, Stambrook and Martin (1983) found that when an emotional face was presented for a duration long enough to allow conscious perception, accuracy in judging the emotion expressed by the face was significantly above chance. When the identical stimuli were presented for shorter exposure durations, negative faces were judged more accurately than neutral faces. In this situation, it is impossible to ascertain whether the results of perception without awareness are due *exclusively* to unconscious perception, or if they are due to some combination of conscious and unconscious perception. Both types of perception would lead to the same pattern of data. In order to separate the effects of unconscious perception from the effects of conscious perception, it is necessary to construct a situation in which these phenomena lead to qualitatively different patterns of results.

The current research builds upon this previous work by placing conscious and unconscious perception in opposition to one another. This is accomplished by using a priming paradigm called the "exclusion task" (see e.g., Debner & Jacoby, 1994). In the exclusion task, a word is presented (e.g., "phone") and is followed by a word stem (e.g., "pho - -"). Participants are instructed to complete the word stem with the first word that comes to mind *other than* the word that was presented. If participants consciously perceived the word, then they will use an alternate word to complete the word stem. If, on the other hand, the participants unconsciously perceive the word, they will often use that word to complete the word stem. Thus, conscious perception should lead to a level of "exclusion failures" that is *below* a baseline level, and unconscious perception should lead to a level of "exclusion failures" that is *above* a baseline level.

The number of trials on which participants claim to have consciously perceived the stimuli will be assessed using a subjective report of awareness. The subjective report of awareness is a question asked of participants regarding how much of the stimulus was perceived. The participants simply state that they saw the entire word, part of it, or nothing at all. Previous research (Smith & Merikle, 2000) has shown that this method accurately reflects the participants' perceptual experiences.

The current research will utilize negative and neutral stimuli and will consist of very brief (17 ms) displays of words to one visual field or the other. Both negative stimuli and the display characteristics should favour the RH. Consistent with previous research in our lab (Smith & Bulman-Fleming, 2001), we would predict that there will be more RH trials than LH trials labeled as being consciously perceived. This difference should be larger for negative than for neutral trials. When stimuli are not consciously perceived, the levels of exclusion failures should be above baseline levels. However, there are two possible patterns that may emerge. One possibility is that the RH will show greater levels of unconscious perception in a pattern similar to the RH advantage predicted for conscious perception. A second possibility is that the RH will show reduced levels of unconscious perception because the RH advantage will manifest itself through an increased degree of conscious perception.

2. Method

2.1. Participants

Sixty-four undergraduate participants (32 males and 32 females) completed this experiment in exchange for monetary remuneration or bonus credit in an introductory psychology course. All participants were right-handed (as determined by the Waterloo Handedness Questionnaire) and had normal or corrected-to-normal vision.

2.2. Stimuli and apparatus

The stimuli consisted of two word sets, each consisting of 120 words ranging in length from five to seven letters. One set of words consisted of *target* words. On target trials, the prime word matched the subsequent word stem (e.g., "phone" followed by "pho - -"). The second set of words consisted of *baseline* words. On baseline trials, the prime word did not match the subsequent word stem (e.g., "bench" followed by "str - -"). See Fig. 1 for a pictorial depiction of these trial types. Both sets of words included 60 negative and 60 neutral items. The emotional content of the words was verified with pre-testing.

For each target item, the word length, emotion type, word frequency (Kucera & Francis (1967) norms), and number of possible word-stem completions were calculated. Each target item was then matched with a baseline word that had equivalent values for each of these four variables. On each trial, one pair of words (target and baseline) was randomly selected with the constraint that each word pair was chosen only once for each participant. *Either* the target word or the baseline word was displayed on a given trial. This selection was randomized with the constraint that each participant was presented 60 target words and 60 baseline words over the course of the experiment.

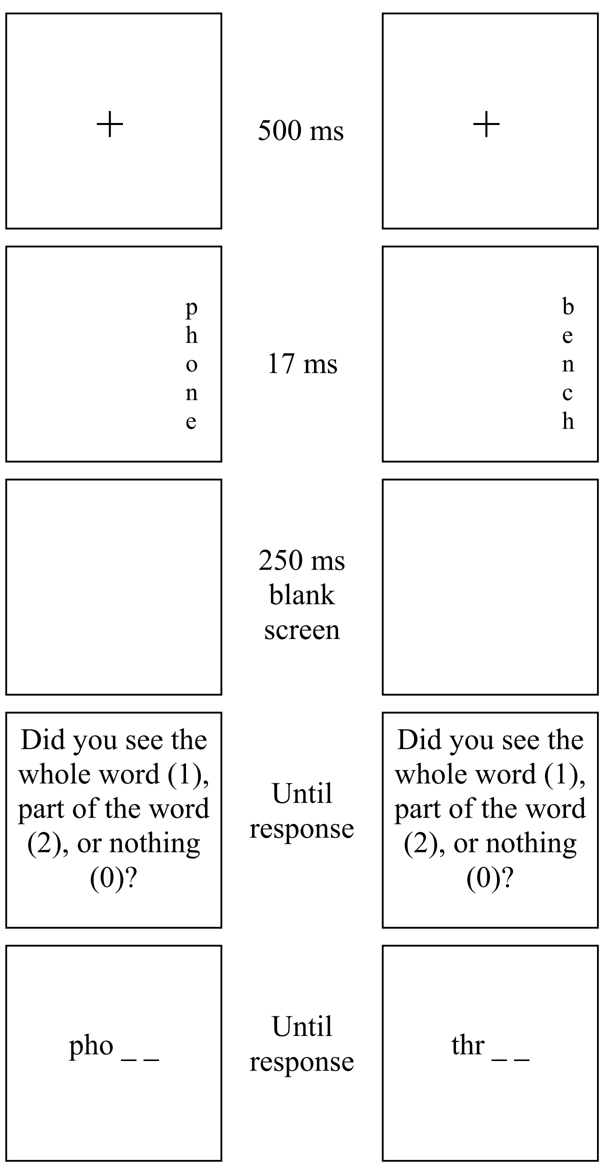

Fig. 1. A depiction of target and baseline trials used in the study.

On each trial, the selected target or baseline word was presented to the left visual field or the right visual field. The side of presentation was randomized with the constraint that each participant would receive an equal number of Negative-Target, Neutral-Target, Negative-Baseline, and Neutral-Baseline words presented to the LVF and RVF. Each word was presented vertically such that the middle letter (the third letter) was presented at the vertical centre of the screen. Words were presented vertically in order to ensure that the end of the word—critical for stem completion—was an equal distance from fixation for both LVF and RVF trials. On average, words measured 4 mm in width and 32 mm in height. The distance from the central fixation cross to the middle letter of the word was 30 mm.

All materials were presented on a 17-in. ViewSonic monitor that was connected to a 450 MHz Pentium II processor. Stimuli were presented using E-Prime 1.0 software. All stimuli were presented in black type font and were displayed against a white background. Participants viewed the displays from a distance of 65 cm.

2.3. Procedure

Participants completed the Positive and Negative Affect Scales (Watson, Clark, & Tellegen, 1988), the Waterloo Handedness Questionnaire (Elias, Bryden, & Bulman-Fleming, 1998), the Waterloo Footedness Questionnaire (Elias et al., 1998), and the Beck Depression Inventory II (Beck & Steer, 1987) before completing two computer tasks.

The first computer task consisted of an "exclusion task" in which participants completed a word stem (e.g., "pho - -") immediately following the display of a word (e.g., "phone"). Each of the 120 trials began with a 500-ms presentation of a fixation cross ("+") that was displayed at the horizontal and vertical centre of the screen. After 500 ms, the cross disappeared and was replaced by a vertically presented word. The word was presented for 17 ms. After a 250-ms blank screen (to avoid masking the stimuli with the sudden onset of another stimulus), the question "How much of the word were you able to see?" appeared on the screen. This question was accompanied by three options. Participants responded as to whether they saw the entire word, part of the word, or nothing at all by pressing a number on the keyboard that corresponded to each option. Each trial ended with the presentation of a word stem. The word stem consisted of three letters and two, three, or four blank spaces to be filled (e.g., "str - -"). Participants were instructed to complete the word stem with the first word that came to mind *other than* the word presented on that trial. Each word stem remained on the screen until the participants entered letters to make a legitimate, English word that filled all required blank spaces. After completing the word stem, participants pressed the spacebar to initiate the next trial.

The second computer task required participants to rate the emotional valence (positive, neutral, or negative) of a series of words on a scale ranging from very positive to very negative. Each trial began with a central fixation cross displayed for 500 ms. Following the disappearance of the fixation cross, a word was presented centrally for 1000 ms. After this presentation, a dialogue box appeared on the screen containing a list of options: Very negative, negative, somewhat negative, slightly negative, slightly positive, somewhat positive, positive, and very positive. Participants were asked to indicate which option corresponded to the word displayed on that trial. All 120 baseline and 120 target trials were presented in a randomized order to each participant.

3. Results and discussion

The number of baseline and target trials in which the word stem was completed with the corresponding target word (hereafter referred to as exclusion failures) was calculated for each participant. The data were analyzed by a $2 \times 2 \times 2$ repeated-measures analysis of variance to evaluate the effects of trial type (target vs. baseline), visual field (LVF vs. RVF), and emotion (negative vs. neutral).

The mean proportions of trials labeled "conscious" and "unconscious" are depicted in Fig. 2. The means for "unconscious" trials consist of both trials on which the participants claimed to have seen part of the word and trials on which participants claimed to have seen nothing. Consistent with previous research (Smith & Merikle, 2000), these two types of trials produced nearly identical patterns of data. They were therefore combined in order to increase statistical power and simplify the analyses. There are two elements of Fig. 2 that are of importance. First, the RH was indeed superior to the LH at consciously perceiving the words for all trial types: $F(1,63) = 16.53,\ p < .05$. This finding replicates previous research (Smith & Bulman-Fleming, 2001) and demonstrates that the RH is superior to the LH at perceiving stimuli presented for brief exposure durations (see Sergent, 1983). Second, when negative and neutral trials

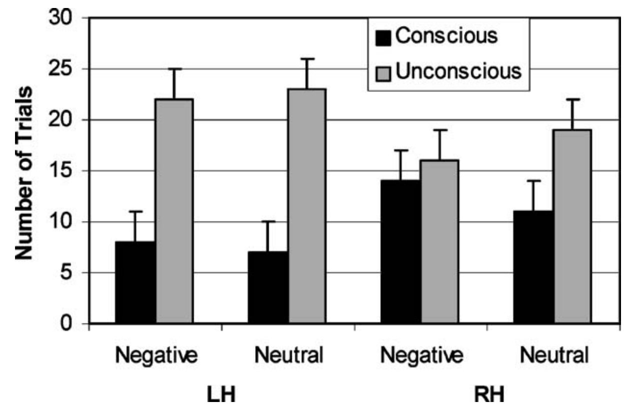

Fig. 2. The mean number of trials labeled as "conscious" or "unconscious" by the participants.

are compared, an interesting difference appears between the hemispheres. There is no difference between the number of negative and neutral trials labeled "conscious" during LH trials ($t < 1$). However, there were significantly more negative than neutral trials labeled conscious during RH trials: $t(63) = 2.66,\ p < .05$. This pattern of results suggests that the RH is superior at perceiving negative emotion compared to the LH, a finding consistent with both the right-hemisphere hypothesis (e.g., Borod et al., 1988) and the valence hypothesis (e.g., Davidson, 1995) of emotional lateralization.

The mean proportions of exclusion failures for baseline and target trials for negative and neutral conditions for LVF and RVF trials are shown in Fig. 3. There are three elements of Fig. 3 that are of importance. First, when words were consciously perceived, participants were able to exclude the target word (i.e., they followed the instructions to use an alternate completion). The proportion of exclusion failures for target trials was significantly below baseline levels for all conditions (t values for all four comparisons were above 6.00). This result confirms

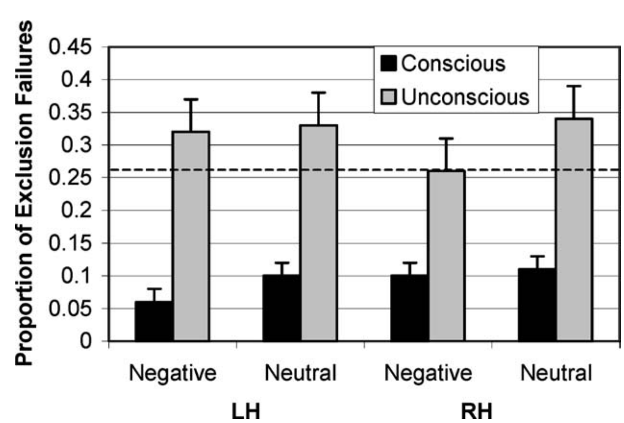

Fig. 3. The mean proportion of exclusion failures found in the current study. The baseline level is indicated by a horizontal, dashed line. Conscious perception is below this baseline level and unconscious perception is above this baseline level.

that the participants did in fact comprehend the exclusion instructions. Second, for trials labeled "unconscious," three of the four trial types showed evidence of unconscious perception. Neutral words presented to the LH ($t(63) = 2.53$, $p < .05$), neutral words presented to the RH ($t(63) = 2.64$, $p < .05$), and negative words presented to the LH ($t(63) = 2.86$, $p < .05$) all showed a proportion of exclusion failures significantly above baseline levels. These results confirm that the display characteristics (i.e., a brief presentation to one visual field) allowed for unconscious perception to occur. Third, the level of unconscious perception for negative words presented to the RH did *not* differ from baseline levels ($t < 1$). This result, coupled with the above evidence of unconscious perception in the other conditions, suggests that the RH advantage found for the conscious perception of negative stimuli occurred at the expense of unconscious perception.

To summarize, the current study demonstrates that when negative emotional stimuli are utilized, the hemispheric asymmetries that occur when items are consciously perceived do not occur when items are unconsciously perceived. Rather, the hemispheric advantage will lead to a greater degree of conscious perception and a reduced degree of unconscious perception. In the current study, this pattern emerged when negative and neutral words were presented in a visual half-field display. The negative words were consciously perceived more often than neutral words when presented to the RH. No difference was evident for LH trials. However, negative words presented to the RH showed no evidence of unconscious perception. Negative words presented to the LH and neutral words presented to either hemisphere all led to a significant degree of unconscious perception. This pattern of data suggests that the advantage found for the conscious perception of negative information by the RH was at the expense of unconscious perception.

The results of the current study lead to several interesting empirical questions. First would be the issue of using solely negative words. We are currently assessing whether positive words will lead to the same pattern of results (thus supporting the right-hemisphere hypothesis) or to an LH advantage for conscious perception (thus supporting the valence hypothesis). We are also examining whether altering the display characteristics to favour the LH (i.e., using masking rather than a brief exposure duration to elicit unconscious perception) will alter the results. Future research will compare positive, negative, and neutral stimuli within the same study, thus allowing us to separate the effects of emotion in general from the effects of specific emotions. Finally, the question of the stimuli themselves must be addressed. Currently, there is no method available to place the results of conscious and unconscious perception in opposition to each other using stimuli other than words (Debner & Jacoby, 1994). Other methods (using emotion-provoking faces or photographs) generally result in contaminated measures of unconscious perception because conscious and unconscious perception lead to the same pattern of data. Thus, to date, it is not possible to determine whether the hemispheric asymmetry found in the current study will generalize to other stimulus types.

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